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DESIGN AND DEVELOPMENT OF A PNEUMATIC GIMBAL ACTUATION SYSTEM

Monthly Technical Report

February 1966

Contract NAS8-5407

Submitted to

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

by

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Monthly Technical Report for February 1966

This report covers activities at the Bendix Research Laboratories Division under Contract NAS8-5407, Modification No. 9, during the period of 1-28 February 1966.

1. TECHNICAL PROGRESS

1.1 Phase I: Gear Motor Development

All room temperature development testing of the gear motor has been successfully completed, and the specified performance parameters have been equaled or surpassed. The motor completed the entire test program without a failure of any part. The only change incorporated in the hardware during the test program was in providing additional porting from the motor to facilitate higher motor speeds. The total exhaust area from the motor, including the valve was finalized at three times the valve supply orifice area. This provided the desired slope to the torque-speed curve without dropping the quiescent motor pressure unnecessarily low.

The actuator was disassembled for visual inspection. It was noted that several of the balls from the ball spline had dislodged during previous testing and had caused some damage to the housing and snubber springs. However, the damage does not appear to be of a magnitude to seriously affect the actuator test schedule.

Revisions to the motor adaptor to facilitate mounting the gear motor on the actuator have been completed.

The vendor delivery schedule for the heat exchanger for cooling the Hydrogen supply gas has been delayed. However the gear motor development program and actuator system test program can be rearranged to perform all room temperature testing first, and the overall schedule will not be delayed.

1.2 Phase II: Epicyclic Motor Development

Detail drawings of all motor components have been completed and are being prepared for release to the shop. An alternate design is being prepared for evaluation and will be fabricated to obtain more motor data for the design guide lines. The second motor will have both ring gears, the active ring gear and balancing ring gear, active, and the displacement chambers will be located between them. This will allow the motor to be somewhat smaller for a given power if it proves to be as efficient as the single active ring design. The motors will be tested to obtain as much data required for establishing a set of motor design parameters for future designs. Special emphasis will be placed on apparent weak points and solutions or improvements will be obtained.

1.3 Phase III: Development of a Photoviscous Technique for Fluid Flow Studies

Black and white photographs of the calibration channel using circularly polarized light were taken for various flow cases, and the photographs were analyzed to determine the relationship of birefringence versus shear rate. A sample of the fluid was withdrawn, and the concentration of milling yellow dye in solution was determined to be 1.4. It was determined that from the resultant plot of birefringence versus shear rate that the apparent concentration appeared to be 1.32 rather than the experimentally determined 1.40. It is felt that the poor correlation of data could be caused by foreign particles other than milling yellow dye showing up in the analysis of the concentration. Due to the fact that the sample is only about 100 grams of solution, the total weight of these foreign particles would only have to be .08 grams to give an error of this magnitude.

The vortex valve was installed on the test stand and photographs were taken for various supply and control flow rates, using both plane polarized white light and circularly polarized monochromatic light. The circularly polarized monochromatic light was used to record the isochromatics, while the plane polarized white light was used to obtain the isoclinics. The reason for using white light rather than monochromatic for recording the isoclinics is that the isoclinics are easier to define in a field of color as opposed to a black and white field. The isoclinic photographs were all taken at the same flow condition, but for different orientation of the angle of the polarizer and analyzer. Since the vortex valve did not provide enough fringes at 25°C to get a good idea of the flow field, the temperature of the fluid was lowered until 3 fringes appeared in the vortex simultaneously at about 50% supply flow. (This flow case was selected arbitrarily.) The fluid temperature required to produce this was about 18°C. The calibration channel was reinstalled and flowed at the same temperature (18.0°C) for flow rates of 10, 20 and 30% flow to provide birefringence versus shear rate data for the vortex valve at this temperature.

A model of a monostable MF-2 amplifier was tested and photographs were taken for 20% supply flow with no control flow and 20% supply flow and 20% control flow, using circularly polarized monochromatic light. The results indicated that attachment would not take place under any circumstance, which concurred with previous test results.

The control panel was installed on the modular enclosure, and the system has been plumbed up and checked for leaks. The model fixture was installed on the writing surface of the cabinet, and the vortex valve was plumbed into the system. The test stand is complete except for the installation of the hardware for the optical system, which at this time has not yet been received.

High speed movies of the starting and stopping transients of the vortex valve were taken using circularly polarized white light. The film speed was varied from 500 to 1000 to 2000 frames per second. An attempt was made to record the transients with monochromatic light, but even at 500 frames per second, the light intensity was too low.

2. PLANS FOR NEXT PERIOD

The actuator will be refurbished and worn or broken parts replaced from the spare parts inventory. The actuator test setup is to be completed to allow debugging the actuator, load simulator, and test procedure, before proceeding with the room temperature actuator system testing.

Fabrication of the DYNAVECTOR actuator with balancing ring will continue during the next period. Design of the actuator with double active rings will be finalized and detail drafting initiated.

Analysis will continue to correlate birefringence versus shear rate data as determined from the calibration channel against the published data in the literature. A new batch of dye will be mixed, and extreme care will be taken in determining the concentration prior to filling the system. The data will then be taken immediately, and another sample will be withdrawn at the completion of the test, and this concentration will be checked.

The photographs of the vortex valve for pure radial flow will be analyzed to determine the radial velocity component as a function of radius. This distribution will be compared with that as predicted from a one-dimensional analysis for the same flow case.

The optical components will be installed on the test stand, which will complete the fabrication.

[redacted]

THE Bendix CORPORATION
RESEARCH LABORATORIES DIVISION

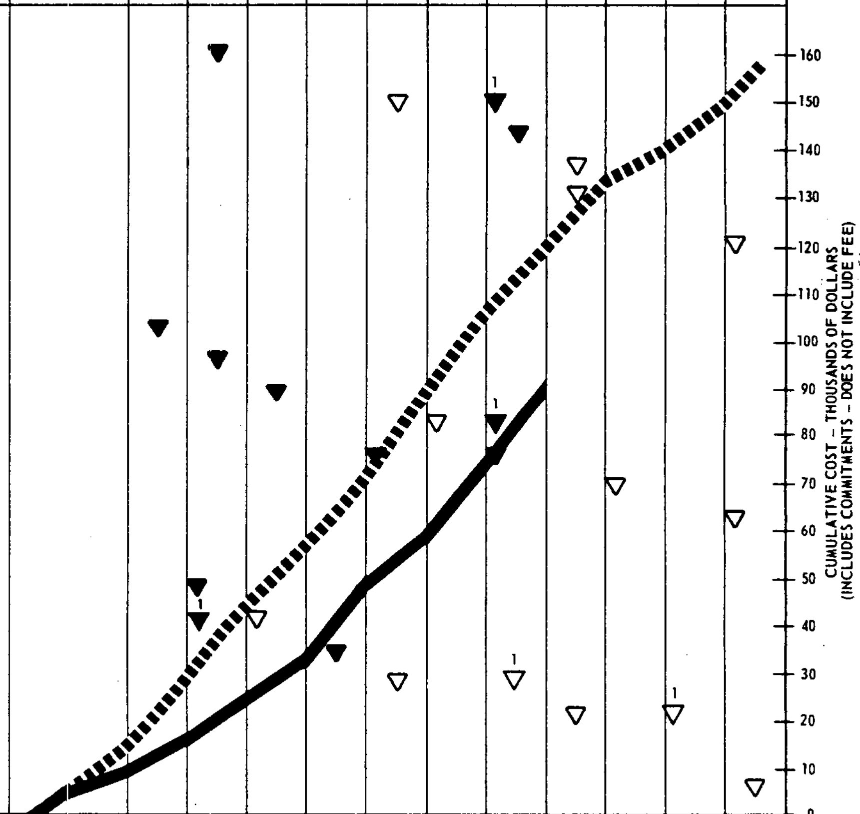
JULY 1965

MILESTONE - CUMULATIVE COST REPORT

"Design and Development of a Pneumatic Gimbal Actuator"

CONTRACT NAS 8-5407
GEORGE C. MARSHALL SPACE FLIGHT CENTER (NASA)

NO.	MAJOR MILESTONES DESCRIPTION	FORECASTED ACHIEVEMENT DATE	ACTUAL ACHIEVEMENT DATE
	PHASE I PNEUMATIC GEAR MOTOR DEVELOPMENT		
1.1	COMPLETE DESIGN AND RELEASE FOR FABRICATION AND PROCUREMENT	9-17-65	9-17-65
1.2	COMPLETE ASSEMBLY	2-1-66	2-1-66
1.3	COMPLETE PERFORMANCE EVALUATION	2-18-66	2-28-66
1.4	COMPLETE REWORK FOR SUBSYSTEMS TESTS	3-18-66	
1.5	COMPLETE CHECKOUT OF NV - B1 ACTUATOR AND ENGINE SIMULATION FIXTURE	3-18-66	
1.6	COMPLETE PERFORMANCE EVALUATION OF NV - B1 ACTUATOR WITH GEAR MOTOR	6-3-66	
	PHASE II EPICYCLIC SERVO MOTOR FEASIBILITY DEMONSTRATION		
2.1	COMPLETE PRELIMINARY BREADBOARD MODEL REQUIREMENTS	8-20-65	8-20-65
2.2	COMPLETE DESIGN ANALYSIS	9-17-65	9-17-65
2.3	COMPLETE COMMUTATION DESIGN STUDY	10-15-65	10-15-65
2.4	RELEASE DESIGN FOR FABRICATION	2-1-66	2-1-66
2.5	RECEIVE SERVOVALVE AND AMPLIFIER FROM MSFC	2-4-66	12-1-65
2.6	COMPLETE ASSEMBLY OF BREADBOARD MOTOR	6-3-66	
2.7	COMPLETE DEVELOPMENT TESTS		
	PHASE III PHOTOVISCOUS FLUID FLOW STUDY		
3.1	COMPLETE LITERATURE SURVEY AND GENERAL ANALYSIS	9-3-65	9-3-65
3.2	COMPLETE SPECIFICATION AND LAYOUT DESIGN OF APPARATUS	10-1-65	9-3-65
3.3	SELECT COMPONENT MODEL FOR STUDY	11-19-65	11-19-65
3.4	COMPLETE FABRICATION AND CHECKOUT OF APPARATUS	2-15-66	
3.5	COMPLETE EXPERIMENTATION AND DATA REDUCTION	5-1-66	
	REPORTING		
	SUBMIT FINAL REPORT	6-16-66	



	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR		MAY	
FORECAST COST (EXCLUDING FEE)	3,000	16,450	29,900	43,900	57,000	72,200	88,500	104,500	119,400	132,402	141,302	150,902	157,902
REVISED FORECAST COST													
ACTUAL COST (INCLUDING COMMITMENTS)	2,985	8,527	16,151	25,248	34,748	51,351	61,955	75,897	90,262				

P-3142

LEGEND: PLANNED MILESTONES ▽ REVISED 1▽ 2▽ ETC.
COMPLETED MILESTONE ▼ ▼ ▼ ETC.
PLANNED CUMULATED COST ▮▮▮▮▮▮ REVISED ▬▬▬
ACTUAL CUMULATED COST ▬▬▬